ATTACHMENT A
SCOPE OF SERVICES
INDIANAPOLIS DEPARTMENT OF PUBLIC WORKS
PHASE 1B GEOTECHNICAL PROGRAM

SECTION A1 - GENERAL DESCRIPTION AND SCOPE OF SUBSURFACE EXPLORATION SERVICES

A1.1 PROJECT DESCRIPTION. The City of Indianapolis, Indiana is planning to construct a combined sewer overflow tunnel. This subsurface investigation is to support design and permitting. These specifications indicate the approximate area of work, estimated quantities, and limits of the work. Approximately 17 borings will be drilled, and 12 piezometers shall be installed. Estimated boring depths are listed in section entitled ESTIMATED BORING DEPTHS.

The Engineer will have a representative or representatives in the field during the field operations. They will observe the work for compliance with this Agreement. They will direct adjustments in the work as required. The field representative will observe the drilling activities, authorize changes in the depth or number of borings, assign the testing listed in the quantity listing, and authorize additions or deletion of borings, piezometers, or field tests. Adjustments to the work which may be required as directed by the Engineer shall be performed or deleted by the Contractor in accordance with these specifications and contract documents and the unit prices stated in ATTACHMENT C: COMPENSATION.

The Engineers representatives will log borings. The Contractor shall provide assistance to the Engineers representatives in performing these functions. This will include retrieval and containerizing of samples, assembly of core boxes, handling of core boxes for review and photography, and transportation of core boxes and samples to the designated storage area or testing facility.

A1.2 DEFINITIONS

"Contractor" shall mean the corporation, company, partnership, firm, or individual who has entered into this Contract for the performance of the work covered thereby, and its, his, or their duly authorized representatives.

"Owner" shall mean City of Indianapolis, City County Building, 200 East Washington Street, Indianapolis, Indiana – 46204, or its duly authorized agents, such agents acting within the scope of the particular duties entrusted them in each case.

"Engineer" shall mean the firm of Black & Veatch, 8720 Castle Creek Parkway, Suite 210, Indianapolis, Indiana, 46250 or its duly authorized agents, such agents acting within the scope of the particular duties entrusted to them in each case.

A1.3 WORK INCLUDED. The work shall include the furnishing of all labor, equipment, materials, tools, supervision, and services required to produce the required subsurface exploration work, including:

Ensuring that all Contractor personnel utilize necessary safety equipment including hard hats, safety glasses, hearing protection, and boots. A site specific safety plan will be required from the Contractor.

Performing all exploratory borings.

Monitoring air at each boring collar with a Photo Ionization Detector (PID) and 4-gas meter for methane and hydrogen sulfide.

Sampling soil by either split barrel or thin walled tube, and rock by core drilling.

Performing water pressure testing in boreholes in rock.

Providing all materials required to protect and preserve soil and rock core samples from damage, freezing, or loss of moisture.

Screening samples using a PID appropriate for the detection of chlorinated solvents and petroleum products.

Collecting soil samples for chemical and environmental testing, and analyzing the samples for sulfates, chlorides, volatile organic compounds using SW-846 Method 8260 and semi-volatile organic compounds using SW-846 Method 8270.

Transporting all samples to the laboratory for testing.

Installing piezometers.

Backfilling borings.

Containerizing, transporting and disposing of all non-hazardous investigation derived wastes, i.e. cuttings, drilling fluids, etc.

Performing laboratory tests and preparing test reports.

A1.4 CHANGES TO SCOPE OF WORK. The Contractor shall add to or deduct from the depth and number of the borings and piezometers indicated on the drawings as directed by the Engineer. The Contractor shall also add to or deduct from the number of each type of laboratory test as directed by the Engineer. Engineer will determine such changes and changes in cost due to changes in quantities will be calculated using unit prices.

A1.5 ACCESS. It is anticipated that access to the property will be available so that work can proceed as scheduled. The Contractor, however, shall have written notification to proceed from the Owner or Engineer before entering the site. If access becomes unavailable as scheduled, the Owner or Engineer will make changes.

The site is in an urban environment, but the investigations will be performed in open areas off of traffic ways and away from pavements. The Contractor shall familiarize himself with the site prior to bidding the work. No clearing of brush to provide access to work areas should be needed and the work areas are accessible to truck and track mounted drilling equipment.

A1.6 SUBSURFACE CONDITIONS. The overburden is approximately 70 to 110 feet thick and consists predominantly of alluvium and glacial outwash; sand, gravel silt, and clay deposits. Boulders and cobbles may be present near the soil rock interface. The bedrock surface in the White River and Fall Creek valley is the New Albany shale at the southern most of the project area; described as grey brown and black shale and minor calcareous shale and argillaceous limestone near base of unit. In downtown Indianapolis and northward in the project area, the New Albany Shale is not present. The New Albany shale is underlain by the Muscatatuck Group that includes the North Vernon Formation described as light gray, tan and white, dense to coarse

grained limestone with common chert, glauconite and phosphate nodules. The Jeffersonville Formation includes the Vernon Fork Member described as relatively pure limestone grading downward to laminated dolomite and the Geneva Member described as light gray through tan and buff to chocolate brown dolomite and dolomitic limestone with white crystalline calcite masses. Some of these units may be missing in certain areas. The Mississinewa Member limestone of the Wabash Formation underlies the Jefferson Formation. Underlying the Wabash Formation are limestone, dolomite, and shale units of Silurian age.

A1.7 SCHEDULE. The work shall begin within 7 days after the award of this Agreement and shall proceed regularly to completion. All field work shall be completed within 10 weeks of starting work. A draft of the completed laboratory test reports shall be submitted to the Owner and Engineer within 4 weeks after the list of requested laboratory tests has been received by the Contractor. The final laboratory reports shall be submitted to the and Engineer within 10 days after receiving comments on the draft laboratory reports.

A1.8 DRAWINGS. The following attached drawings indicate the location of the borings and piezometers.

SITE VICINITY MAPS/LOCATION PLAN
ATTACHMENT D

A1.9 UNIT PRICES. All work not specifically set forth as a pay item shall be considered a subsidiary obligation of the Contractor and all costs in connection therewith shall be included in the prices stated in ATTACHMENT C: COMPENSATION.

The unit prices stated in ATTACHMENT C: COMPENSATION shall include all fixed charges, making exploratory borings, installing piezometers, securing samples of rock and soil, performing field and laboratory tests, and reporting results of field and laboratory tests. The anticipated quantities of the work are indicated in ATTACHMENT C: COMPENSATION. The Engineer, based upon information obtained during the investigation, will determine the final quantities.

A1.9.1 Mobilization. An initial mobilization of two drill rigs and associated equipment is required. A third drill rig shall be available as required to meet the schedule of the work. The mobilization unit price is for the complete mobilization cycle, including delivery to and removal from the plant site of all materials, tools, and drilling, sampling, and testing equipment. The mobilization unit price also includes obtaining all necessary drilling permits and insurance, daily travel to and from the project site, and moving materials, tools, and equipment between borings. If additional mobilization is initiated by a written request from the Owner or Engineer, additional payment will be made in the amount of the appropriate unit price stated per drill rig. A site specific safety plan shall be submitted by the Contractor prior to mobilization.

No payment will be made for mobilization costs for equipment brought to the site to replace equipment which breaks down or does not perform satisfactorily, or is found to be unsuitable for site conditions. No payment will be made for mobilization costs for conditions brought about by adverse weather.

A1.9.2 Drilling and Sampling Field Work. The following unit prices shall include all costs of labor, materials, and equipment.

The unit price for **boring in soil** shall include the cost of making rotary wash or auger borings, drilling mud, and all other appurtenant drilling costs including containerizing, transporting and disposing of non-hazardous investigation derived wastes. Payment for borings in soil shall be

made on the basis of actual depth of boring advanced, measured from the ground surface to the depth authorized by the Engineer. Boring in soil may be required with or without sampling.

The unit price for **temporary casings** shall include the cost of supplying, installing, and removing all temporary casings. No payment shall be made for temporary casings left in place because of impracticability of removal. Payment for temporary casings shall be made on the basis of actual depth installed, measured from the ground surface. Payment for temporary casing shall not be paid for hollow stem augers.

The unit prices for **split barrel sampling** shall include cleaning the bottom of the hole before making penetration tests, making standard penetration tests, recovering representative samples of soil from each test, and all other appurtenant costs including the cost of containers and labels for samples.

The unit price for **thin walled tube sampling** shall include the cost of cleaning the bottom of the hole before sampling, recovering samples, and all other appurtenant costs including the cost of materials for sealing samples. No payment will be made for recovered thin walled tube samples disturbed by careless handling or inappropriate sampling procedures as judged by the Engineer.

The unit price for **core boring in rock** shall include the cost of making the HQ-sized borings, recovering the core, and all other appurtenant costs, including the cost of boxes for cores and materials for preserving samples. Payment for core borings will be made on the basis of actual length of core drilled.

The unit price for initial **set-up to start packer testing** shall include all costs for labor, materials, and equipment to assemble the packer testing apparatus. Payment shall be made at the lump sum price for each set-up, regardless of the number of consecutive tests performed following set-up. It is anticipated that there will be one initial set-up charge per boring.

The unit price for conducting **water pressure testing** using a single or double packer system to isolate 10 to 20 ft intervals of the bedrock shall included all costs for labor, materials, and equipment to perform the tests in the field. The test time will begin when the packer assembly is first placed and successfully inflated in the borehole and end when the packer assembly is removed from the borehole after completion of the last test interval. The test time shall include no time lost due to the malfunction of equipment or Contractor's absence.

The unit price for **backfilling completed boreholes** shall include the cost to backfill the completed boreholes, including the cost of cement and bentonite materials; and completion and submission of all regulatory required forms. Payment for backfilling completed boreholes shall be made on the basis of actual depth backfilled, measured from the ground surface to the bottom of the borehole. If the borehole has collapsed before backfilling, the quantity shall be measured from the ground surface to the depth of the collapse as determined by the Engineer.

The unit price for installation of **piezometers** shall include the cost of installing filter, screen, riser pipe, bentonite seal, and grout; and the developing the piezometer. Payment shall be made on the basis of the actual length of pipe installed, including the riser above the ground surface.

The unit price for **flush mount protective enclosure** will be made on the basis of the number of piezometer protective enclosures installed.

The unit price for **per diem** shall include all daily expenses for all of the Contractor's personnel on site. Daily expenses shall include food, sleeping accommodations, daily travel, and other daily expenses. The per diem unit price shall be for each person involved in the work on a daily basis

for all days from the first day to the last day of subsurface investigation work. Per Diem will not be paid for site clearing and cleanup days.

The unit price for **standby time** shall be an hourly rate that includes the cost of all labor and equipment that is at the site but is not working due to specific orders from the Engineer or Owner. Standby time shall be agreed to, and approved, by both the Contractor and the Engineer's field representative. Standby time will not be paid for any down time brought about by adverse weather, mechanical problems, or for travel time.

A1.9.3 Laboratory Tests. The unit price for each laboratory test shall include all costs of labor, materials, and equipment for performing the tests and presenting test results.

A1.10 ESTIMATED QUANTITIES. Estimated quantities of work are included in ATTACHMENT C: COMPENSATION.

ATTACHMENT A
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SECTION A2 - DETAILED SPECIFICATIONS FOR EXPLORATORY BORINGS, PIEZOMETERS, AND FIELD AND LABORATORY TESTING

A2.1 GENERAL. This section covers the detailed technical requirements of the work for exploratory borings, piezometers, and field and laboratory tests required for the work.

Boring logs and piezometer installation logs will be recorded and prepared by the Engineer. The Contractor will receive a copy of the Engineer's preliminary logs for the Contractor's billing purposes if requested by the Contractor.

A2.2 ESTIMATED BORING DEPTHS. The following list of borings shall be used as the basis for this proposal. The Engineer will determine actual depths in the field, based on subsurface conditions encountered.

Boring #	Orientation	Overburden ft (approx.)	Rock ft (approx.)	Pressure Testing in Rock	Backfill ~ ft	PZ ~ ft
B-1A	Vertical	50	0	0	0	50
B-2	Inclined 20º from Vertical	85	200	20	285	0
B-4	Vertical	90	180	18	40	230
B-7	Vertical	80	180	18	40	220
B-8	Vertical	80	180	18	40	220
B-9	Inclined 20º from Vertical	85	190	19	275	0
B-10A	Vertical	50	0	0	0	50
B-11	Vertical	80	180	18	40	220
B-12	Inclined 20º from Vertical	85	190	17	275	0
B-14	Vertical	90	170	17	30	230
B-16	Inclined 20º from Vertical	85	190	19	275	0
B-18	Vertical	80	180	18	30	230
B-19	Inclined 20º from Vertical	85	180	18	265	0
B-20B	Vertical	80	170	17	40	210
B-21	Vertical	90	0	0	0	90
B-22	Vertical	90	0	0	0	90
B-23	Vertical	80	170	17	40	210
Total		1,365	2,360	318	1,675	2,050

A2.3 REFERENCE STANDARDS. Wherever an ASTM designation is cited in this document, it shall mean the American Society for Testing and Materials Standard Specification of that designation appearing in the most recent edition of the "Annual Book of ASTM Standards," published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania, USA. Other equivalent standards may be substituted if acceptable to the Engineer.

A2.4 SURVEYING. The Contractor shall use Owner or Engineer designated benchmarks and/or staked locations to locate the borings. The Contractor shall not start work at any location until that location has been staked and the Owner or Engineer has issued authorization to proceed. Locations of the borings shall be as generally shown on drawings included in these specifications.

A2.5 ROTARY WASH BORINGS. Rotary wash borings shall include soil drilling and sampling. The Contractor shall provide drilling mud or temporary casing if required to maintain an open hole. Temporary casing may be required to stabilize the hole while advancing the boring. The casing shall be steel pipe of the size required by the drilling equipment and may be either new material or used material in good condition. The Engineer will document the size, length, and placement information on the boring log. No payment will be made for temporary casing left in place because of impracticability of removal.

A2.6 AUGER BORINGS. Auger borings shall be made by a machine driven auger at least 4-inches in diameter. Unless otherwise accepted by the Engineer, auger borings shall be performed in accordance with ASTM D1452. Hollow stem augers may be used if sufficient inner diameter is available to accommodate a 3-inch OD thin walled tube sampler or an HQ size core barrel.

Auger borings shall not be drilled in granular soils below the water table unless permitted by the Engineer.

A2.7 ROCK CORING. Rock coring will be required in some of the borings. Rock coring shall be performed in accordance with ASTM D2113, except as otherwise specified herein or accepted by the Engineer. All rock coring shall be performed with high speed drilling machines specifically designed for rock coring and sampling. Water shall be used as the drilling fluid. No drilling fluid additives shall be allowed except for an organic polymer additive specifically approved by the Engineer.

Except as otherwise specified, core barrels shall be in accordance with ASTM D2113, Double or Triple Tube, Swivel-Type, "M"-design or better with split inner tube, or shall be equivalent barrels acceptable to the Engineer. Each core barrel shall have a core lifter suitable for catching and retaining cores in soft formations.

Core bits shall be in accordance with ASTM D2113, selected to provide the maximum core recovery, and acceptable to the Engineer.

Core barrels shall not be longer than 10 feet, unless otherwise accepted by the Engineer. Special care shall be taken to ensure that maximum recovery is obtained on each section of core.

Core runs shall be limited to 5 feet or less, if in the opinion of the Engineer such limit is needed to assure acceptable core recovery. Runs of 1 or 2 feet may be required to obtain acceptable core recovery in soft or broken material. The core shall be pulled whenever necessary to prevent loss or damage to the core. Grinding of the core after the core barrel has been blocked will not be permitted and a blocked core barrel shall be pulled regardless of the interval desired.

After each core run, the core barrel shall be opened by splitting the inner tube and the core will be logged by the Engineer while it is still contained in an undisturbed condition in one of the barrel halves. Only after the core run is logged will the core be removed from the inner tube halve and placed in the core box.

Rock cores from each boring shall be placed in Contractor-furnished suitable durable boxes in accordance with ASTM D5079. Sturdy core boxes made out of wood shall be used for the

purpose of storing rock cores. Cardboard or plastic boxes shall not be used. Core boxes shall be provided with hinges on one side and lockable latches on the other. Wooden spacers shall be furnished for separating core runs and for identifying the location of core losses. Under no condition shall cores from more than one hole be placed in the same box. The Contractor will label each box for identification in a manner acceptable to the Engineer.

Core samples for laboratory testing shall be selected and preserved according to ASTM D 5079 immediately after a run has been logged and before the natural moisture content changes. The location of samples shall be marked with suitable, labeled spacers in the core boxes.

Rock cores that deteriorate upon exposure to air shall be preserved according to ASTM D 5079 immediately upon recovery. The Contractor shall furnish all materials for preserving the rock cores and shall be responsible for preserving, boxing, and handling the cores at the site. The Engineer will label the cores for identification.

A2.8 BOREHOLE COLLAR MONITORING. The collar of each boring (top of casing) shall be monitored with a 4-gas meter for methane and hydrogen sulfide. The collar and samples retrieved from the soil shall also be monitored using a Photo Ionization Detector with a bulb suitable for detection of chlorinated solvents and petroleum products.

A2.9 SAMPLING METHODS AND FREQUENCY. Soil sampling in borings shall consist of split barrel samples on 2.5-foot intervals to a depth of 10 feet. Below a depth of 10 feet, until rock is encountered, sampling shall consist of split barrel samples every 5 feet.

If cohesive soils are encountered, samples shall be taken at depths listed above, but thin walled tube samples shall be alternated with split barrel samples as directed by the Engineer.

The water level in each hole shall be maintained whenever drilling equipment is retracted in preparation for sampling to avoid unbalanced hydrostatic pressure that might wash in material from the sides and bottom of the hole or make the hole unstable.

A2.10 SPLIT BARREL SAMPLING. Split barrel samples shall be obtained and the resistance to soil penetration shall be measured in accordance with ASTM D1586. Penetration resistance (blow count) for all three 6-inch increments will be required. Sample jars for split barrel samples shall be wide mouth, 1-pint, moisture-proof glass jars provided by the Contractor.

A2.11 THIN WALLED TUBE SAMPLING. Thin walled tube samples shall be obtained in accordance with ASTM D1587. Tubes shall recover a sample at least 3 inches in diameter. Tubes shall be furnished by the Contractor in 30 to 36-inch lengths and shall either be constructed of seamless steel tubes or welded seam tubes provided welds do not project at the seam. Tubes shall be clean and free of corrosion. Tube samples shall not be extruded in the field. The Contractor shall keep the samples in their original sampler until the sample is to be tested.

If the recovery of a thin walled tube sample is less than 12 inches in length, a split barrel sample shall be obtained. The cost of recovering the lost portion of thin walled tube samples, when less than 12 inches is recovered, shall be included in the price for thin walled tube samples.

A1.12 ENVIRONMENTAL SAMPLING. If Photo Ionization Detector readings indicate the presence of chlorinated or petroleum solvents and fuels in the soil, soil samples will be collected by the Engineer for volatile and semi-volatile organic analyses using SW-846 Method 8260 and SW-846 Method 8270. The Contractor shall be responsible for providing the appropriate glass sample jars, jar labels and chilled cooler to storage and transport the samples to the laboratory for

testing. The Contractor shall be responsible for transportation of the cooler to the laboratory and for completing and reporting (Level II data) the analytical tests.

A2.13 BACKFILLING. After the 24 hour water level reading or when directed by the Engineer, the Contractor shall backfill the inclined borings with grout. Grout for backfilling shall consist of equal parts cement and bentonite mixed with no more water than is required for proper placement. Cement shall conform to ASTM C150, Type 1. The grout shall be thoroughly mixed and shall be used before any stiffening occurs. The grout shall be placed by tremie starting from the bottom of the boring.

The Contractor shall verify that the backfill method complies with any government requirements.

If mud pits have been used during the drilling operations, they shall be completely backfilled with tamped soil backfill, which shall be compacted to a density equivalent to the natural density of the adjacent soil.

A2.14 WATER PRESSURE TESTING. After completion of rock core borings, wireline packer testing shall be performed over the specified borehole depth intervals.

The Contractor shall provide the following:

Pump, water, high pressure, progressive cavity (Moyno type), capable of producing 50 gpm at 150 psi
Meter, water (measures flow accurately to +/-0.1 gallon, calibrated)
Gauge, pressure (psi, calibrated, 1 psi graduation)
Nitrogen inflatable Packer system, pneumatic, capable of sealing the cored borehole, rated for minimum of 350 psi
Nitrogen supply
Tank, surge
Valve bypass (for regulating water pressure)
Miscellaneous pipe fittings
Hose, air, high pressure (1/4" I.D.)
Nitrogen cylinder with pressure regulator and two pressures gauges
Pressure transducer with sufficient cable length to place the transducer in the test interval
Read-out box to measure the pressures at the transducer, in psi
100 ft. tape
Drill rig and crew equipped with all required hand tools pipe vise, etc.
Sufficient clean water to complete each test without interruption

The Engineer in charge of the water pressure test operations is responsible for obtaining all necessary information and for performing such tests correctly. Any measurements of doubtful accuracy must be noted, along with a description of the questionable aspects. Under the direction of the Engineer, testing should be continued until all uncertainties or contradictions have been resolved.

Criteria for locating water pressure test sections in a borehole will be established by the Engineer.

Pneumatically expandable packer units are required, and mechanically expandable units shall not be used, because of the superior pressure seal between the packer and borehole wall created by the pneumatic unit.

Downhole pressure transducer placed in the middle of the test interval shall be required.

The first test zone in the water pressure testing sequence shall be conducted in the borehole at the greatest depth below ground surface. Subsequent test zones shall proceed in sequence up the borehole at progressively shallower depths.

A surge tank is required to be used in performing water pressure tests. The surge tank insures that a constant non-pulsating flow of water is pumped into the test section during the duration of testing.

In the event that the Contractor supplying the gauges, meters and testing equipment cannot provide recent calibration charts for the various items, the Engineer may require field or laboratory calibration tests on the applicable items (refer to Calibration Procedures).

A2.14.1 Packer Test Calibration and Borehole Preparation. Recent calibration certificates by an authorized laboratory must accompany all water meters, transducers, read-out boxes, and pressure gauges.

Advance the holes and casing through all the overburden soils and seat casing in bedrock. Drill the bedrock portion of the borehole with a 3.5 inch O.D. (HQ size) core barrel. Flush the borehole with clean fresh water, until all the cuttings are removed. If an organic drilling fluid had been approved by the Engineer and used, Johnson's "Fast-Break" or an equivalent acceptable to the Engineer shall be added to the borehole prior to pressure testing in accordance with the manufacturer's recommendations.

Evaluate the type and quality of the rock cored, considering the presence of any discontinuities that could affect the test procedures or results.

The field engineer will determine the allowable Baseline Pressure (PBL) for each test in order to avoid hydrofracturing or dislocations in the rock mass. Do not exceed the PBL during testing, however it may be reduced, depending on the physical condition of the rock mass in the test zone as well as in the packer sealing areas.

The PBL will vary with each test, as it is directly relate to the test depth below ground surface. Existing or proposed hydrologic conditions in the test area also affect the PBL. Under normal conditions the PBL is calculated as follows:

$$PBL = LR*K+LS*0.5$$

LR = depth below top of rock to the midpoint of the test zone
LS = thickness of soil cover above top of rock

In general, the PBL is calculated as 1.0 psi per foot of rock cover and 0.5 psi per foot of soil cover above the middle of the interval being tested.

The constant, K, is a function of rock type and quality well as of the vertical stress and static water pressure at the test zone. If the bedrock is of good quality (RQD = 75% to 100%) the constant K = 1; however, if bedrock is of low quality (RQD = 0 to 50%) the constant K should be less than 1.0. When testing in concrete or cemented blocks the value of K should vary between 0.5 and 0.75 as precaution against washing out old and possibly friable cementation. Generally one constant may be calculated for a specific project, but major site variations may require a “Variable Constant” for each test location. The Engineer, based on information received from the Engineer, will determine the constant to be used for the specific site situation.
Record all pertinent data.

A2.14.2 Packer Test Procedures

a. Lower the test apparatus to the desired depth for testing as determined by the Engineer. After making all water and pneumatic connections, run pump until water return in the casing is observed to be free of air bubbles. This is done in order to purge the entire system of air. Failure to do so may cause, under certain conditions, the compression of the air left in the system, and water will appear to be flowing into the rock while it is only compressing the air.

b. The spacing between the packers is typically within 10 feet; however this spacing may be adjusted in the field by the Engineer to meet the requirements of the specific test.

c. The applied packer assembly pressure is variable, subject to equipment type, rock quality and static water pressures. Hard rubber inflatable packers (Lynes type) are inflated in the range from 150 to 600 psi. Soft rubber packers (Damco type) are inflated in the range from 100 to 300 psi.

d. The water pressure test is conducted according to the Lugeon pattern of data collection. Pump water under pressure into the portion of the borehole to be tested. Adjust the water pressure to pressures of 1/2 (low pressure) and 3/4 (medium pressure) of the PBL and record water flow readings every minute for 5 minutes for each of the low and medium pressures. Adjust the water pressure to the PBL peak pressure and again hold for 5 minutes with water flow readings every minute. Repeat the procedure of recording the water flow with elapsed time descending order for high to low pressure after reaching PBL.

e. During any of the test stages outlined above, if water is observed to flow from top of casing, or the entire test apparatus tends to move in the borehole, it is an indication of leakage of water between the packers and the rock walls of the borehole. In that event, increase pneumatic seal pressure while continuing to pump water until the flow over the top of the casing is completely stopped. If bubbles are observed, it is an indication of gas leaking from packers or conduits, necessitating removal of test assembly from borehole to correct the problem. Occasionally the discontinuities in the rock mass, such as open joints, may transmit water upwards and into the casing. If such a flow persists following an increase in the pneumatic seal pressure it is considered an intake by the rock mass.

f. Water pressure tests should be run using clean water in order to minimize friction losses in the system, and through the rock mass. Record all irregularities that may occur during the test, such as leakage, running out of water, etc.

g. If leakage of water from the test section into the surrounding rock is so great that the PBL cannot be reached, run the pump at its full capacity with the bypass valve closed: record the amount of water pumped into the test section, at 60-second intervals, with associated pressure readings for a minimum of 5 minutes.

h. If rock in test section will not “take” water at PBL, check conditions in vicinity for any indications of unusually high hydrostatic pressure, i.e. artesian condition or nearby high surface water level. However, in most cases the rock mass will not take water because of the general tightness of the discontinuities. If water take does not occur at any of the Test pressures (1/2, 3/4 of PBL, and PBL), the test may be terminated without following the

descending order of pressure. If water take occurs in any of the test pressures, the entire cycle of ascending and descending test pressures must be performed.

i. Upon completion of the test, deflate the packers while the water pump is running and allow one or two minutes of water flow. Observe the water meter (gallons) and be sure there is an unrestricted flow through the system. This is especially important during the winter months since water may freeze inside the meter under no-flow conditions. Under no circumstances shall regular automotive-type antifreeze be used. It is detrimental both to the environment and to the testing equipment. A special antifreeze is commercially available and may be used as approved by the Engineer.

j. If the test does not produce desired pressure and flow information, advise Engineer before demobilizing from site.

A2.15 PIEZOMETER INSTALLATION. The Contractor shall furnish or subcontract all labor, materials, and equipment for completing the installation of piezometers as specified herein.

Piezometers shall be installed in accordance with ASTM D5092 and as described below. Risers for piezometers shall consist of 2 inch diameter, Schedule 80 PVC pipe or other material acceptable to the Engineer. The lower 30 feet of each riser shall be slotted screen section with 0.01 inch wide slots. The bottom of each riser shall be capped.

PVC pipe sections shall be joined using water tight, threaded flush joints that are acceptable to the Engineer. Glued joints are not acceptable.

Bentonite drilling mud shall not be used to advance a piezometer borehole. An equivalent organic polymer drilling fluid acceptable to the Engineer may be used, provided that the manufacturer's directions are carefully followed. If any drilling fluid other than clear water is used, the borehole shall be pressure washed using side discharge bits.

Sand shall be used as filter pack around the slotted section and shall extend 3 feet above the slotted section. The sand shall extend 12 inches below the bottom of the riser pipe for piezometers. Sand shall be placed in a slow, steady stream around the piezometer. Sand shall be washed silica sand that is appropriate for use with a 10-slot screen and has a uniformity coefficient less than 2.5.

Directly above the filter pack shall be a 24 inch impervious clay bentonite pellet seal and above the bentonite seal, the entire length of the piezometer shall be backfilled to the ground surface with cement-bentonite grout.

Each well installation shall be provided with a flush mounted traffic-rated locking enclosure to secure the well head. All padlocks for the well enclosures shall be keyed alike and the keys provided to the Engineer upon well completion. The flush-mounted enclosure shall consist of a flat cast-iron threaded, removable cover; a threaded, cast-iron outer ring; and a steel or cast-iron skirt. The protective enclosure shall be a Brianard-Kilman Model TC-253, or equivalent. The removable cover shall screw onto the outer ring, and a gasket shall provide a watertight seal between the cover and ring. The cover shall be designed so a special tool is required to remove it. The Contractor shall provide the Engineer with two tools required to open and close the cover. The enclosure shall be embedded below the ground surface and the top of the enclosure shall be 1 inch above existing grade. In addition, the Contractor shall permanently label the well enclosure with the well number on the outer ring surface using a metal stamp and on the inside of the enclosure with metal tags.

A 24-inch square-formed diameter structural concrete surface seal shall be placed from a depth of 18 inches to the top of the flush-mounted cover. The concrete shall slope away from the cover

and shall be finished with a smooth uniform surface using a trowel or float. The piezometer identification number shall be etched in the concrete of the front facing right-hand corner, as indicated by the Engineer. Pressure treated wood forms are acceptable to construct the 24-inch square forms for the finished concrete pads.

Following installation of the piezometer, filter pack, and backfilling to the ground surface, the piezometer shall be developed by air lifting or pumping until the discharge water is clear as determined by the Engineer and soundings indicate all loose material has been removed from the piezometer. If an organic drilling fluid had been approved by the Engineer and used, Johnson's "Fast-Break" or an equivalent acceptable to the Engineer shall be added to the piezometer prior to development in accordance with the manufacturer's recommendations. The Contractor shall measure the water level in each piezometer 24 hours after completion, and provide to the Engineer immediately.

A2.16 WATER. The Contractor shall furnish all water required for drilling and other work as required. No separate payment will be made for water or for time spent getting water. All water used shall be free from oil, acids, organic materials, or other deleterious substances

A2.17 DISCHARGE WATER. Discharge water from the boring operations shall be conveyed to natural drainage by piping or ditches acceptable to the Owner or Engineer. The Contractor shall ensure that discharging of water shall be in accordance with all federal, state, and local requirements. At the conclusion of the work, the Contractor shall repair all erosion damage caused by the discharge water and restore ditches and other drainage facilities to their original condition.

A2.18 CLEANUP. At the conclusion of the work at each work location, the Contractor shall remove all equipment, tools, material, and supplies, and shall leave the site clean and clear of all debris generated by his work and restore the site to its original condition.

A2.19 LABORATORY TESTING. Unless otherwise permitted by the Engineer, each laboratory test shall be performed as specified in the laboratory test standards specified hereinafter. Test results shall be reported on forms suitable for reproduction and shall be as acceptable to the Owner and Engineer. Hand written laboratory test results will not be acceptable. All original laboratory test data and calculation sheets shall be submitted to the Engineer. All final reports of test results shall be in English.

Samples to be tested will be selected by the Engineer after completion of the drilling. The Contractor shall be responsible for delivering the test samples to the laboratory.

A2.19a LABORATORY TESTING FOR SOIL SAMPLES.

Moisture Content. Moisture content determination shall be as specified in ASTM D2216.

Atterberg Limits. Atterberg limits shall be as specified in ASTM D4318. The liquid limit shall be determined be securing the results of at least three trials. The test report shall include initial moisture content.

Grain Size Analysis. Grain size analysis shall be as specified in ASTM D422, with sample preparation by ASTM D2217 (wet preparation method), Procedure B. This test is a complete sieve analysis, not just a measurement of the percent finer than the number 200 sieve. This test does not include a hydrometer analysis. If the Engineer or Owner requires hydrometer analyses, they will be requested separately. Reports of the results of this test shall include data and a graph of the data.

Hydrometer Analysis. Hydrometer analysis shall be as specified in ASTM D422, with sample preparation by ASTM D2217 (wet preparation method), Procedure B. Reports of the results of this test shall include data and a graph of the data. This test does not include a sieve analysis for the portion of the soil larger than a No. 200 Sieve. If the Engineer or Owner requires sieve analyses, they will be requested separately.

Consolidation. Consolidation tests shall be as specified in ASTM D2435 except as specified herein. Loading increments shall be as required by the Engineer upon assignment of the test. Each consolidation test shall include one rebound and reload cycle. When the specimen is saturated, if the specimen begins to expand the load shall be increased as required to hold the specimen at its original height. The test report shall include the log of time versus deformation plot for each load increment.

Unconfined Compression - Soil. Unconfined compression tests of cohesive soil shall be as specified in ASTM D2166. The unconfined compression test on soils shall be performed using controlled strain procedure. The test report shall include a plot of stress versus strain.

Extrude and Log Thin Walled Tube Sample. Select thin walled tube samples shall be extruded in the laboratory and a sample description shall be prepared as requested by the Engineer. The sample description shall include the measured length of sample recovered and a visual classification of the sample in accordance with ASTM D2488. Other laboratory tests may be performed on the extruded samples as requested by the Engineer. The extruded samples shall be protected against disturbance and loss of moisture after extrusion and prior to additional testing.

Chemical Analysis. Chemical analysis of samples selected by the Engineer shall be by U.S. Environmental Protection Agency (EPA) methods. Chemical analysis shall include percent chlorides (EPA method 9038) and percent sulfates (EPA method 325.3).

Environmental Analysis. Environmental analysis of samples collected by the Engineer shall be analyzed for volatile organic analysis by SW-846 Method 8260 and semi-volatile analysis by SW-846 Method 8270.

A2.19b LABORATORY TESTS FOR ROCK CORE.

Unconfined Compression. Unconfined compression tests of rock cores shall be as specified in ASTM D2938 at the natural moisture content of the rock. The test report shall include initial dry unit weight, initial moisture content, and a plot of stress versus strain.

Rock Moduli in Uniaxial Compression. The deformation moduli of rock cores shall be determined at the natural moisture content as specified in ASTM D3148. The test report shall include initial dry unit weight, initial moisture content, and plots of stress versus strains.

Bulk Density. Bulk density determination for rock cores procedure shall be as described in "Suggested Methods for Rock Characterization, Testing and Monitoring," by the International Society of Rock Mechanics Commission on Testing Materials, 1981.

Splitting Tensile Strength. The splitting tensile strength (Brazilian Test) of rock cores shall be as specified in ASTM C3967.

Punch-Penetration Test. Punch-penetration tests shall be as conducted by the Colorado School of Mines Excavation Engineering and Earth Mechanics Institute (Colorado School of

Mines, Excavation Engineering and Earth Mechanics Institute at 1500 Illinois Street, Golden, CO 80401).

Slake Durability Test. Slake durability tests on rock cores shall be as specified in ASTM D4544.

Cerchar Abrasivity Index Test. Cerchar abrasivity index tests shall be conducted by the Colorado School of Mines Excavation Engineering and Earth Mechanics Institute.

Direct Shear Strength. Direct shear strength tests on rock cores shall be as specified in ASTM D5607-95.

Thin Section Analysis. Thin section analysis shall be conducted as described in "Suggested Methods for Petrographic Description of Rocks," by the International Society of Rock Mechanics, 1977.

A2.20 BORING AND PIEZOMETER LOGS. The Engineer will prepare boring, piezometer, and water pressure testing, logs. The Contractor shall assist the Engineers representative in obtaining and containerizing samples; boxing, labeling, preserving, and photographing core; monitoring and recording test data. Copies of the logs will be made available to the Contractor upon request.

A2.21 REPORTS. A data report containing only the final laboratory test reports shall be submitted to the Engineer. Five bound and two unbound copies of the report shall be provided to the Engineer. No other reports, such as a geotechnical engineering report, are required. Laboratory test results shall be reported to the Engineer as specified in the section titled LABORATORY TESTS.

A2.22 DOWNHOLE VIDEO LOGGING. Downhole video logging shall be conducted by the Engineer on up to eight borings to view the in-situ orientation and characteristics of fractures, bedding planes, joints, and solution features. Video logging shall generally be conducted on the borings that exhibited the highest conductivity as determined by water pressure testing. The Contractor shall assist the Engineer's representative with the downhole video logging.

A2.23 PHASE 1A AND PHASE 1B BORING CORES AND SAMPLES. For the Phase 1B Geotechnical Programs, the Contractor shall transport and store cores at a DPW-designated facility, as directed by the Engineer (Southport Wastewater Treatment Plant). The Contractor shall also transport the cores obtained during the Phase 1A Geotechnical Investigation to the Southport Wastewater Treatment Plant for storage. For the Phase 1A cores and samples, the Contractor's scope is based on the Phase 1A cores being loaded, transported from a facility in Charlestown, Indiana to the Southport Wastewater Treatment Plant in Indianapolis, and unloaded in the designated storage area. The Contractor shall assist the Engineer's representative with opening and closing Phase 1A core boxes and stacking the boxes as directed by the Engineer.